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Let Q be the mean position of the pole of figure of the Earth, and let us assume that the actual pole P revolves around it in a radius a, and in a period of one year. Let R be the position of the pole of rotation at any time. Then, at each moment, R is revolving around the fixed position P with a uniform motion, which, if continued, would cause it to complete a revolution in 427 days. Let us put

n, the mean motion of the radius PQ;

μ, the mean motion of R around the position of P;

x, y, the rectangular co-ordinates of R referred to Q as an origin.

The law of rotation then gives the equations

$$\frac{dx}{dt} = -\mu y + a\mu \sin (nt + c)$$

$$\frac{dy}{dt} = \mu x - a\mu \cos (nt + c).$$

The integration of these equations gives

$$x = \alpha \cos \mu t - \beta \sin \mu t - \frac{a\mu}{n-\mu} \cos (nt + c)$$

$$y = \alpha \sin \mu t + \beta \cos \mu t - \frac{a\mu}{n-\mu} \sin (nt + c),$$

α and β being arbitrary constants.

Substituting for μ and n their numerical values, we have, approximately,

$$x = \alpha \cos \mu t - \beta \sin \mu t + 6a \cos (nt + c)$$

$$y = \alpha \sin \mu t + \beta \cos \mu t + 6a \sin (nt + c).$$

Such a rotation as we have supposed, around a circle of $0''\cdot05$ in radius, would suffice to produce anomalies as large as those actually observed.

If the winters in Siberia and in North America occurred at opposite seasons, we should have no difficulty in accepting the sufficiency of annual falls of snow to account for the anomaly. But, under the actual circumstances, we must await the results of further investigations into the whole subject.

On the Displacement of the Apparent Radiant Points of Meteor-Showers due to the Attraction, Rotation, and Orbital Motion of the Earth. By Joseph Kleiber.

The question of the shifting or immobility of radiant points of meteoric showers has been lately discussed with warmth from the point of view of several observers, in the pages of these *Notices* and elsewhere. As no theoretical investigation into this subject has yet appeared, I trust that the following lines

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may be of some interest, and may help to elucidate this question which has been the subject of so much controversy.

There are three principal causes of the displacement of the apparent radiant of a meteor shower. These are—

1. The *attraction* of the Earth.
2. The *rotation* of the Earth.
3. The *orbital motion* of the Earth.

I shall consider these causes separately in the order here indicated, and trace the theoretical curves described by a radiant under the separate influence of each of them, and of the three conjointly, and shall illustrate the theory by applying it to two characteristic examples.

i. The *Perseid swarm*, which is the one chiefly concerned in the discussion alluded to above, and which will furnish an especially good illustration of the *third* of the causes just mentioned;

ii. The *Andromedid swarm*, whose position is especially adapted for illustrating the displacement of a radiant due to the *first* of these causes, and to show how a diffused radiation may be the consequence of the action of this first cause alone.

I. *The Attraction of the Earth.*

The displacement of a meteoric radiant due to the attraction of our planet on every meteor of the shower consists in the fact that the meteors of a swarm describe hyperbolas about the Earth's centre as a focus, instead of describing straight lines, and that the apparent direction of a meteor's path is determined by the direction of the tangent to this hyperbola at the point where it meets the Earth's atmosphere, instead of being determined by the direction of its asymptote—the latter representing the undisturbed path of the meteor. The amount of this displacement, *i.e.* the angle between the tangent to the meteor's visible track and the asymptote, or the direction of its undisturbed motions depends—

(i.) On the relative velocity of the meteors with respect to the Earth; and

(ii.) On the angle between the direction of the path of the meteors, and their radius vector from the Earth's centre, *i.e.* the zenith distance of their radiant.

Formulæ for the computation of the value of this displacement were given more than twenty years ago by G. V. Schiaparelli in his classic work on shooting stars, and they need not be repeated here. Only the final result will be given and applied to numerical examples.

The attraction of the earth *diminishes the zenith distance* of every radiant, leaving its azimuth unchanged.

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Let w be the undisturbed relative velocity of the meteors of a particular shower, and w_1 their relative velocity accelerated by the attraction of the Earth. Then the equation of *vis viva* gives

$$w_1^2 = w^2 + 2gr.$$

Let Δz be the difference between the disturbed and undisturbed zenith distance of the radiant, and

$$\Delta z_0 \text{ the value of } \Delta z \text{ when } z = 90°,$$

i.e. when the radiant is on the horizon; then Schiaparelli finds—

$$\tan \tfrac{1}{2}\Delta z_0 = \frac{w_1 - w}{w_1 + w},$$

and also

$$\tan \tfrac{1}{2}\Delta z = \tan \tfrac{1}{2}\Delta z_0 \tan \tfrac{1}{2}z.$$

These are the formulæ we shall use in our *second* example. In the particular cases when Δz_0 is small, the following approximate formulæ are more convenient:—

$$\Delta z = c \tan \tfrac{1}{2}z$$

$$c = \frac{a}{w^2} \qquad (\log a = 2{\cdot}941).$$

The usual astronomical units being used, the formulæ give c and Δz in degrees, and Δz having been computed, $\Delta\alpha$ and $\Delta\delta$ may be found from known formulæ.

Example 1. *Perseids.*—Among the many different positions given for the radiant of this swarm, it is difficult to make a choice which will not be to a great extent arbitrary. Again, as all these radiants are deduced from observations uncorrected for any of the three causes here considered, it would be inconsistent to start from values which will be shown to differ sensibly from those that would have been found if appropriate methods were used in the determination of radiants. I prefer, therefore, to take the radiant of the comet 1862 iii. in its node, and to apply to it the corrections here indicated.

The orbit of the comet does not geometrically intersect that of the Earth; but we may dispose of the value of its period of revolution or major axis, so as to give it a real point of intersection. Thus, if we take the following elements of this comet:—

$$\pi = 289\overset{\circ}{\cdot}78$$

$$\Omega = 137{\cdot}45$$

$$i = 113{\cdot}57$$

$$\phi = 74{\cdot}01,$$

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we shall find for the co-ordinates of the radiant point

$$\alpha = 43^\circ\!\cdot\!58$$
$$\delta = 57\cdot08.$$

These values correspond to the epoch when $\odot = 137^\circ\cdot45 (= \Omega)$, *i.e.* approximately to August 9·5 (Greenwich time). The periodic time of the comet, or rather of the meteoric swarm moving in the comet's orbit, is found to be 122·9 years, when the orbit of this swarm and that of the Earth really intersect in the node of the former.

From this position of the undisturbed apparent radiant I find that the *elongation of the radiant from the Earth's apex, i.e.* the angle between the direction of the motion of the Earth and the direction of the apparent radiant, is

$$\epsilon = 39^\circ\cdot90,$$

and hence *the relative velocity* of the comet in its node is found to be 2·02 times that of the Earth at the same moment, or, in usual astronomical units,

$$\log w = 8\cdot5354,$$

and the abridged formulæ of this section give

$$c = 1^\circ\cdot03.$$

This is the largest displacement which could be produced on the radiant of the *Perseids* by the attraction of the Earth, if the radiant ever reached the horizon; but this radiant never sets at Greenwich (for which place we are computing all our results), and thus the so-called *zenith-attraction* never attains this value.

In order to give a clear idea of the influence of this disturbing cause on the positions of the radiant at different hours of the night, I have computed the corrections $\Delta\alpha$, $\Delta\delta$, to be applied to its co-ordinates for every three hours, beginning at the moment when the hour angle is 0, and ending twenty-four hours later.

The formulæ for the computation of these corrections are

$$\Delta\alpha \cos\delta = -\Delta z \sin Q$$
$$\Delta\delta = -\Delta z \cos Q,$$

Q being the "parallactic angle."

By means of these formulæ and the figures given above, I find the following corrections :—

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TABLE I.

t	*z*	Q	Δ*z*	Δα	Δδ	T
h	°	°	°	°	°	h
0	5·6	180·0	−0·05	0·00	−0·05	6
3	26·4	82·7	−0·24	+0·44	+0·03	9
6	48·9	55·7	−0·47	+0·71	+0·26	12
9	65·3	29·0	−0·66	+0·59	+0·58	15
12	71·4	0·0	−0·74	0·00	+0·74	18
15	65·3	331·0	−0·66	−0·59	+0·58	21
18	48·9	304·3	−0·47	−0·71	+0·26	0
21	26·4	277·3	−0·24	−0·44	+0·03	3
	5·6	180·0	−0·05	0·00	−0·05	6

The last column gives the approximate mean time corresponding to the values indicated in the table.

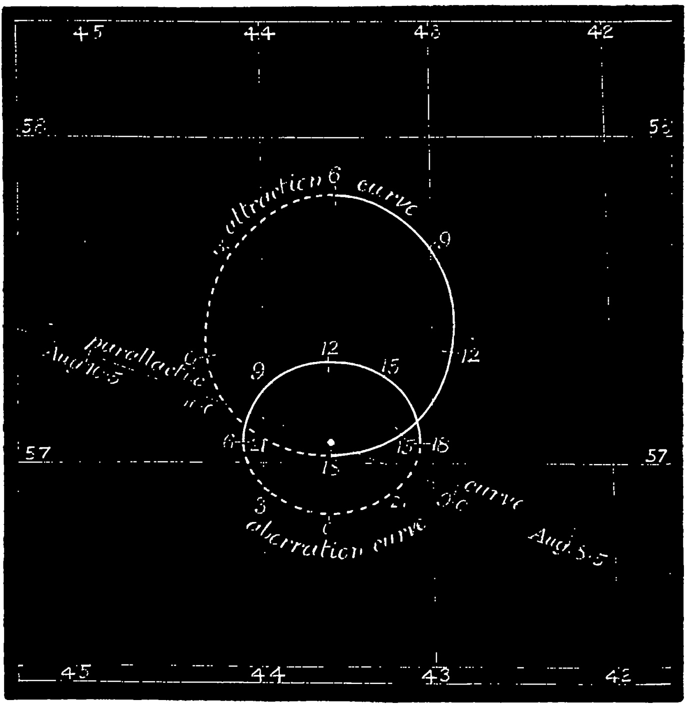

Fig. 1.

Fig. 1 illustrates this table. The attraction curve is an oval described by the radiant in twenty-four hours. The figures along the curve denote the mean Greenwich time of the corresponding position as given in the last column of the table above. We see from the diagram that the undisturbed position of the radiant differs not only from its real position (so far as it is affected by the attraction of the Earth alone) at any particular moment, but also from the mean position of the disturbed radiant during a whole period, the radiant lying very eccentrically in the oval described by its successive disturbed positions.

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Example 2. *Andromedids.*—Very differentis the case of the *Andromedid* swarm. The meteors of the *Perseid* shower possess a large relative velocity, and the disturbing action of the Earth's attraction on the position of its radiant is accordingly comparatively small. The relative velocity of the *Andromedids* is, on the contrary, of the very smallest, and the disturbing action due to the Earth's attraction on them is consequently enormous.

I take here again, as in the former case, the cometary radiant to start from. The elements of the comet Biela being

$$\pi = 108^{\circ}\!\cdot\!97$$

$$\Omega = 245\cdot97$$

$$\iota = 12\cdot57$$

$$\phi = 49\cdot03.$$

I find for the position of the radiant in the node of the cometary orbit the co-ordinates

$$\alpha = 23^{\circ}\!\cdot\!27$$

$$\delta = 43\cdot12.$$

The epoch of the swarm is approximately November 27·5 (corresponding to $\odot = 245^{\circ}\cdot97$), and the periodic time of the meteoric swarm is found to be 6·72 years, when the orbit of this swarm and that of the Earth intersect in a real point.

From these data the elongation of the radiant from the Earth's apex is found to be

$$\epsilon = 113^{\circ}\cdot73,$$

and hence the relative velocity of the swarm in its node is equal to 0·53 of the Earth's orbital velocity at the same time; in astronomical units

$$\log w = 7\cdot9592$$

This gives for Δz_0 the enormous value $11^{\circ}\cdot70$! But the radiant of this swarm also never sets in the latitude of Greenwich. In the same way as in the former example, I find the following values of z, Q, Δz, $\Delta\alpha$ and $\Delta\delta$ for every three hours of the hour angle t from t=0 to $t=24^{\mathrm{h}}$.

TABLE II.

t	z	Q	Δz	$\Delta\alpha$	$\Delta\delta$	T
h	°	°	°	°	°	h
0	8·4	0·0	− 0·86	0·00	+ 0·86	15
3	31·1	58·4	− 3·25	+ 3·80	+ 1·71	18
6	57·7	47·4	− 6·45	+ 6·65	+ 4·36	21
9	76·7	26·8	− 9·28	+ 5·72	+ 8·26	0
12	85·4	0·0	− 10·80	0·00	+ 10·80	3
15	76·7	26·8	− 9·28	− 5·72	+ 8·26	6
18	57·7	47·4	− 6·45	− 6·65	+ 4·36	9
21	31·1	58·4	− 3·25	− 3·80	+ 1·71	12
24	8·4	0·0	− 0·86	0·00	+ 0·86	15

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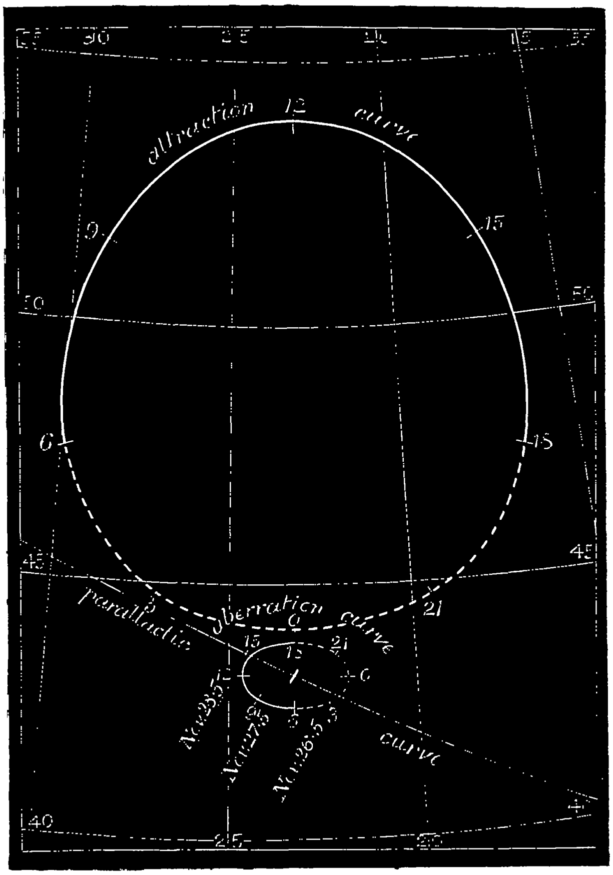

Fig. 2.

Fig. 2 illustrates this table. The attraction curve is here a very large oval, the undisturbed radiant being not inside but *outside* the curve, and *at a distance of about six degrees from its central point.*

II. *The Rotation of the Earth.*

1. *Perseids.*—This cause produces a small aberration of the radiant, never amounting to more than one degree in arc, at the latitude of Greenwich. The displacements $\Delta\alpha$, $\Delta\delta$ may be computed by means of the following formulæ, analogous to those used in the computation of the aberration of light.*

$$\Delta\alpha = -0^{\circ}{\cdot}52 \cos t$$

$$\Delta\delta = -0{\cdot}23 \sin t$$

whence I find the following table of corrections.

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* These formulæ were first indicated by R. Lehman-Filhés in his *Inaugural-Dissertation: Zur Theorie der Sternschnuppen,* Berlin, 1878.

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TABLE III.

t	$\Delta\alpha$	$\Delta\delta$	T
h	°	°	h
0	−0·52	0·00	6
3	−0·37	−0·17	9
6	0·00	−0·23	12
9	+0·37	−0·17	15
12	+0·52	0·00	18
15	+0·37	+0·17	21
18	0·00	+0·23	0
21	−0·37	+0·17	3
24	−0·52	0·00	6

This table is illustrated in Fig. 1 by the *aberration curve*—a small ellipse described by the radiant about its mean position.

2. *Andromedids.*—In the same way I find for the November shower

$$\Delta\alpha = -1^\circ\!\cdot\!45 \cos t$$
$$\Delta\delta = -0\cdot72 \sin t$$

which gives the following table of corrections :—

TABLE IV.

t	$\Delta\alpha$	$\Delta\delta$	T
h	°	°	h
0	−1·45	0·00	15
3	−1·03	−0·51	18
6	0·00	−0·72	21
9	+1·03	−0·51	0
12	+1·45	0·00	3
15	+1·03	+0·51	6
18	0·00	+0·72	9
21	−1·03	+0·51	12
24	−1·45	0·00	15

The small *aberration curve* in Fig. 2 illustrates the displacement of this radiant due to the rotation of the Earth.

III. *The Orbital Motion of the Earth.*

The orbital motion of the Earth plays a very important part in determining the position of the apparent radiant, provided that the observations of meteors belonging to the same shower extend over a long period of time. In fact, the apparent radiant is given by the direction of the diagonal constructed on the absolute velocities of the Earth and meteors respectively, but the directions of the tangents to the orbits described by the Earth and a meteoric swarm change every moment, and are widely different in different points of space ; thus, if the meteor shower be very

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extended, so that its meteors are seen during several successive days, or even weeks, the position of its apparent radiant must be different for each day. We shall now proceed to the computation of this most important part of the apparent displacement of radiants.

Two views may be taken *à priori* of the subject. First, a meteor shower may constitute a ring (or part of a ring) having a definite orbit in the solar system. In this case the elements ι, $\pi - \Omega$ (and ϕ if the orbit is an ellipse) are constant for all parts of the ring. Or, secondly, the meteor stream may be considered as the result of the disintegration of an agglomeration of independent cosmical particles which enter the solar system from external interstellar space*; in this case the elements of every portion of the stream must be different, whereas the heliocentric position of the aphelion or perihelion of the orbit is the same for every portion.

The first supposition—which will prove to be the true one at least in the case of the *Perseids*—leads to a very simple rule for the displacement of the apparent radiant of a meteoric ring, viz. :—

The latitude of the radiant remains constant, its longitude increases (approximately) *proportionally to time.*—In other words, if A be the longitude of the Earth's apex, then the quantities $l - A$, C are constant for every radiant—with a very small correction due to the eccentricity of the Earth's orbit; *i.e.* the radiant moves uniformly in a circle parallel to the ecliptic. The proof of this rule is very simple. It is known that the elements ι and $\pi - \Omega$ of a parabolic meteoric orbit are completely determined if the values of $l - A$ and C are given; and *vice versâ*, if ι and $\pi - \Omega$ are given and have constant values, the co-ordinates $l - A$, C must have constant values too. For elliptic orbits $l - A$, C and ϕ completely determine ι and $\pi - \Omega$; and conversely, ι, $\pi - \Omega$ and ϕ completely determine $l - A$ and C. Thus, in every case the radiant of a meteor-shower will move according to the rule given above.

This rule forms an excellent test both for the theory and for the observations. If a series of radiant points be given, belonging to the same meteoric shower, and observed during a long period of time, we have only to express their positions in longitude and latitude instead of in right ascension and declination, and to subtract from the longitude of each radiant the longitude of the Earth's apex at the same moment; *then all the radiants must coalesce in one point.*

Of course we cannot expect a perfect coincidence of all radiants after this operation; the inevitable errors of observation, the inaccurate method used in determining the position of the radiant points from observed meteor-paths, the neglected corrections due to the attraction and rotation of the Earth; all

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* This view has been taken by Mr. Hoek in a paper published in the *Monthly Notices.*

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these causes agree in displacing the observed radiant point from its true position, and the combined effect of these causes may, even in the more favourable case of a swarm like the *Perseids*, easily amount to several degrees.

The observations of Mr. Denning on the *Perseid* swarm extend over a period of almost six weeks (July 8–August 16). During this time the radiant describes, according to Mr. Denning, an arc extending *fifty-seven degrees* in right ascension and *ten degrees* in declination. The identification of points so distant from one another as one and the same radiant has been objected to; doubts have been expressed as to the possibility of a real connection between these different radiations, and more cogent reasons than the mere resemblance in the physical appearance of their meteors have been asked for.

Now if we perform on all the forty-nine radiants indicated in Mr. Denning's catalogue as belonging to the *Perseid* shower, the operations explained above, we obtain a result which supports Mr. Denning's (and our) view on these radiants even better than could be expected.

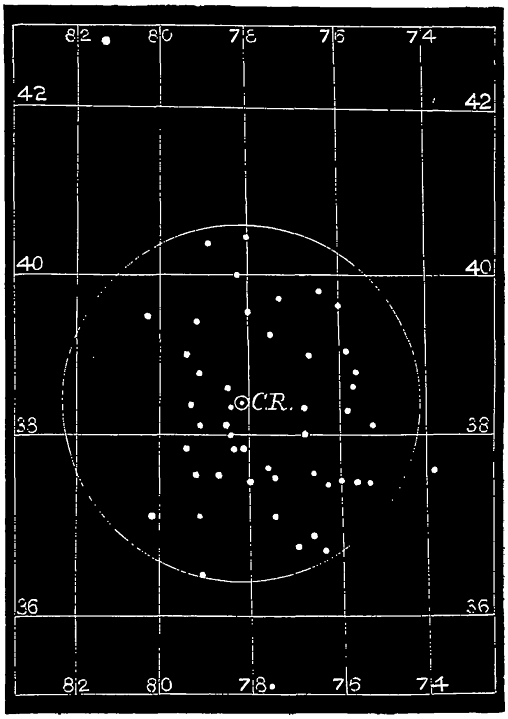

Fig. 3.

Fig. 3 shows the positions of all these radiants after the reduction,* *i.e.* after the parallactic correction has been applied

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* I do not here give the details of the calculation as they are incorporated in the "Catalogue of Meteoric Orbits" appended to my Treatise *On the Determination of Orbits of Meteor-Showers*, St. Petersburg, 1891 (in Russian, with an abstract in English), on pp. 279–291. The ecliptical co-ordinates l, b of the radiants are given there, together with the differences $\odot^1 - l$, where $\odot^1 = A - 90°$. The fig. gives the positions of these points in the co-ordinates $\odot^1 - l$, b.

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to them, together with the position of the cometary radiant. It will be seen that out of the forty-nine radiants *forty-six lie within a circle described about the cometary radiant with a radius of two degrees*, three only being outside this circle, and of these the two remotest at a distance of 4½° and 3½° respectively. These two last are precisely the first and last of the series; the first corresponding to July 8 and deduced from *five* meteor tracks only, and the last, on August 16, deduced from eight observations, and I hope that fresh data will bring them still nearer to the cometary radiant.*

It remains now to consider the real motion of a meteoric radiant as it results from the combined action of the three disturbing causes. The *parallactic curve* is drawn in Figs. 1 and 2, together with the two other curves described above, and the position of the radiant on it on three consecutive days is indicated. Combining the displacements due to the attraction and aberration of the radiant with its parallactic motion, I find, for the *Perseids* and *Andromedids*, the following positions on three consecutive days, and for every three hours of each day :—

Table V.

(*Perseids*) $\alpha_0 = 43^\circ{\cdot}58$ $\delta_0 = 57^\circ{\cdot}08$

	T	$\Delta\alpha_3$ parallactic	$\Delta\alpha_1 + \Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_3$	$\Delta\delta_1 + \Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate. α	Ultimate. δ
	h	°	°	°	°	°	°	°	°
Aug. 8	0	−2·01	+0·71	−1·30	−0·42	+0·03	−0·39	42·28	56·69
	3	−1·85	+0·95	−0·90	−0·39	+0·41	+0·02	68	57·10
	6	−1·68	+0·52	−1·16	−0·35	+0·74	+0·39	42	47
	9	−1·51	−0·23	−1·74	−0·32	+0·75	+0·43	41·84	51
	12	−1·34	−0·71	−2·05	−0·28	+0·49	+0·21	53	29
	15	−1·17	−0·80	−1·97	−0·24	+0·20	−0·04	61	04
	18	−1·01	−0·52	−1·53	−0·21	−0·05	−0·26	42·05	56·82
	21	−0·84	+0·08	−0·76	−0·18	−0·14	−0·32	82	76
Aug. 9	0	−0·67	+0·71	+0·04	−0·14	+0·03	−0·11	43·62	97
	3	−0·51	+0·95	+0·44	−0·11	+0·41	+0·30	44·02	57·38
	6	−0·34	+0·52	+0·18	−0·07	+0·74	+0·67	43·76	75
	9	−0·17	−0·23	−0·40	−0·04	+0·75	+0·71	18	79
	12	0·00	−0·71	−0·71	0·00	+0·49	+0·49	42·87	57
	15	+0·17	−0·80	−0·63	+0·04	+0·20	+0·24	95	32
	18	+0·34	−0·52	−0·18	+0·07	−0·05	+0·02	43·40	10
	21	+0·51	+0·08	+0·59	+0·11	−0·14	−0·03	44·17	05

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* The theoretical position of the cometary radiant on July 8 is $\alpha = 9^\circ$, $\delta = 46^\circ$; Mr. Denning's values are $\alpha = 3$, $\delta = 49$; also for August 16 our theory gives $\alpha = 54^\circ$, $\delta = 59^\circ$, while Mr. Denning finds from his observations $\alpha = 60^\circ$, $\delta = 59^\circ$.

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	T	$\Delta\alpha_3$ parallactic	$\Delta\alpha_1+\Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_3$	$\Delta\delta_1+\Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate. α	δ
	h	°	°	°	°	°	°	°	°
Aug. 10	0	+0·67	+0·71	+1·38	+0·14	+0·03	+0·17	44·96	57·25
	3	+0·84	+0·95	+1·79	+0·18	+0·41	+0·59	45·37	67
	6	+1·01	+0·52	+1·53	+0·21	+0·74	+0·95	11	58·03
	9	+1·17	−0·23	+0·94	+0·24	+0·75	+0·99	44·52	07
	12	+1·34	−0·71	+0·63	+0·28	+0·49	+0·77	21	57·85
	15	+1·51	−0·80	+0·71	+0·32	+0·20	+0·52	29	60
	18	+1·68	−0·52	+1·16	+0·35	−0·05	+0·30	74	38
	21	+1·85	+0·08	+1·93	+0·39	−0·14	+0·25	45·51	33
Aug. 11	0	+2·01	+0·71	+2·72	+0·42	+0·03	+0·45	46·30	53

Fig. 4 illustrates this table.

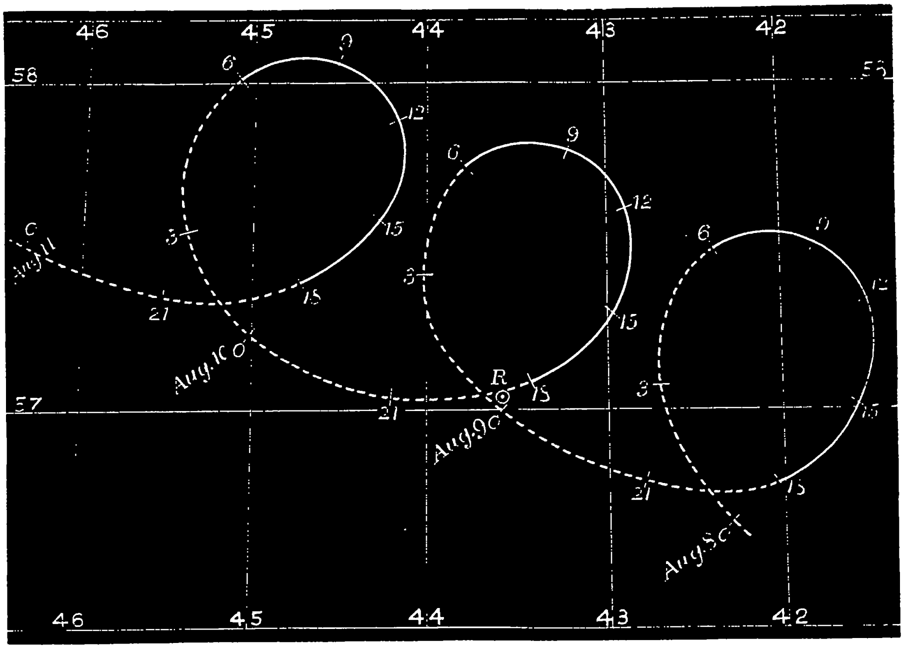

Fig. 4.

TABLE VI.

(*Andromedids*) $\alpha_0=23^\circ{\cdot}27$ $\delta_0=43^\circ{\cdot}12$

	T	$\Delta\alpha_3$ parallactic.	$\Delta\alpha_1+\Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_3$	$\Delta\delta_1+\Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate. α	δ
	h	°	°	°	°	°	°	°	°
Nov. 26	0	−1·62	−4·69	−6·31	−0·87	+8·77	+7·90	16·96	51·08
	3	−1·48	−6·65	−8·13	−0·80	+5·08	+4·28	15·14	47·40
	6	−1·35	−4·83	−6·18	−0·72	+2·22	+1·50	17·09	44·62
	9	−1·22	−1·45	−2·67	−0·65	+0·86	+0·21	20·60	43·33
	12	−1·08	+2·73	+1·65	−0·58	+1·20	+0·62	24·53	43·78
	15	−0·94	+6·65	+5·71	−0·51	+3·64	+3·13	28·98	46·25
	18	−0·81	+6·75	+5·94	−0·44	+7·55	+7·11	29·21	50·23
	21	−0·68	+1·45	+0·77	−0·36	+10·80	+10·44	24·04	53·56

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	T	$\Delta\alpha_3$ parallactic.	$\Delta\alpha_1+\Delta\alpha_2$	$\Sigma\Delta\alpha$	$\Delta\delta_3$	$\Delta\delta_1+\Delta\delta_2$	$\Sigma\Delta\delta$	Ultimate. α	Ultimate. δ
	h	°	°	°	°	°	°	°	°
Nov. 27	0	−0·54	−4·69	−5·23	−0·29	+ 8·77	+ 8·48	18·04	51·60
	3	−0·40	−6·65	−7·05	−0·22	+ 5·08	+ 4·86	16·22	47·98
	6	−0·27	−4·83	−5·20	−0·14	+ 2·22	+ 2·08	18·07	45·20
	9	−0·14	−1·45	−1·59	−0·07	+ 0·86	+ 0·79	21·68	43·91
	12	0·00	+2·73	+2·73	0·00	+ 1·20	+ 1·20	26·00	44·32
	15	+0·14	+6·65	+6·79	+0·07	+ 3·64	+ 3·71	30·06	46·83
	18	+0·27	+6·75	+7·02	+0·14	+ 7·55	+ 7·69	30·29	50·81
	21	+0·40	+1·45	+1·85	+0·22	+10·80	+11·02	25·12	54·14
Nov. 28	0	+0·54	−4·69	−4·15	+0·29	+ 8·77	+ 9·06	19·12	52·18
	3	+0·68	−6·65	−5·97	+0·36	+ 5·08	+ 5·44	17·30	48·56
	6	+0·81	−4·83	−4·02	+0·44	+ 2·22	+ 2·66	19·25	45·78
	9	+0·94	−1·45	−0·51	+0·51	+ 0·86	+ 1·37	22·76	44·49
	12	+1·08	+2·73	+3·81	+0·58	+ 1·20	+ 1·78	27·08	44·90
	15	+1·22	+6·65	+7·87	+0·65	+ 3·64	+ 4·29	31·14	47·41
	18	+1·35	+6·75	+8·10	+0·72	+ 7·55	+ 8·27	31·37	51·39
	21	+1·48	+1·45	+2·93	+0·80	+10·80	+11·60	26·20	54·72
Nov. 29	0	+1·62	−4·69	−3·07	+0·87	+ 8·77	+ 9·64	20·20	52·76

Fig. 5 illustrates this table.

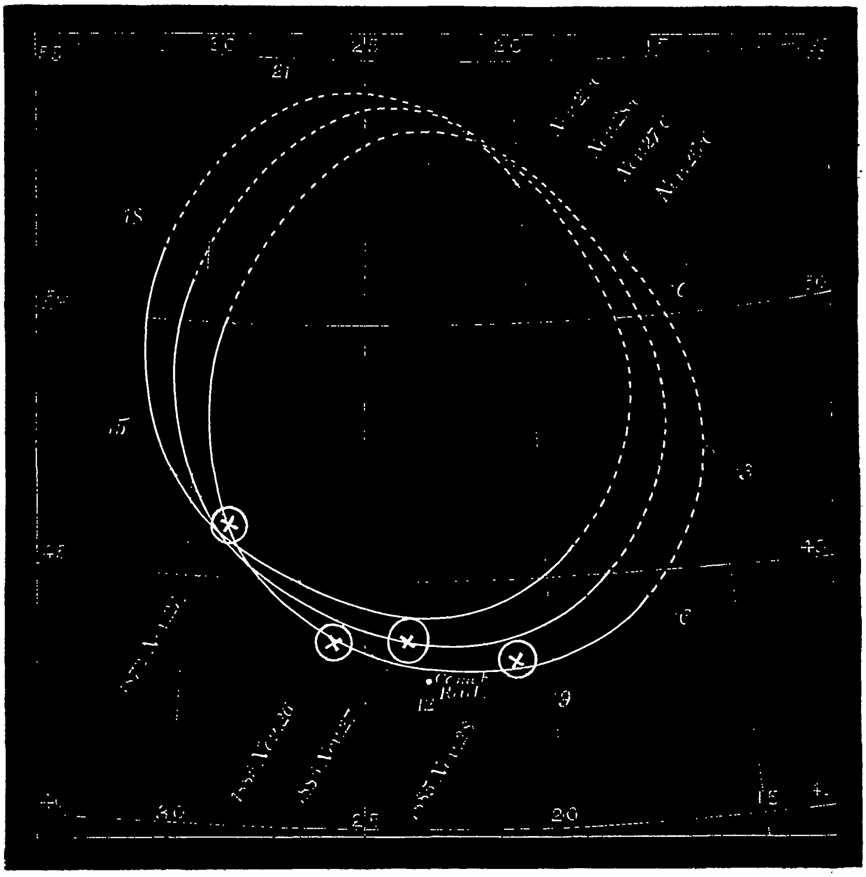

Fig. 5.

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It may now be seen how difficult and complicated a problem it is to find a radiant point from a series of observations of meteor tracks extending over some length of time.

The accurate method would be the following:—

From a few meteor paths traced on a celestial chart an approximate position of the radiant is to be found; from this the three corrections should be determined for every observation of a meteor; the corrected paths of the meteors again mapped, and then a more accurate position of the radiant may be found.

On the large Sun-spot of 1892 *February* 5–18, *and the Associated Magnetic Disturbance.*

(*Communicated by the Astronomer Royal.*)

As the large spot seen on the Sun 1892 February 5–18 was the largest which has been photographed at Greenwich, and as its presence appears to have been associated with a great magnetic disturbance, some particulars may be of interest, though they must necessarily be imperfect pending the arrival of photographs from India and Mauritius to supplement the Greenwich series.

At Greenwich photographs of the Sun were obtained on five days during the first appearance of the group, viz. on February 5, 13, 16, 17, and 18; and up to the present time on three days during its second appearance, viz. on March 5, 7, and 8. The following table gives the heliographic coordinates of the centre of the great spot, and the total area of the entire group, expressed in millionths of the Sun's visible hemisphere, for each day of observation during its first appearance:—

Date. G. Civil T.			Distance from Centre in terms of Sun's Radius.	Position-Angle from Sun's Axis.	Heliographic			Area.	
					Longitude from Central Meridian.	Longitude from Prime Meridian.	Latitude.	Umbra.	Whole Spot.
	h	m		°	°	°	°		
Feb. 5	10	24	0·985	118·4	−81·9	259·0	−29·0	96	1522
13	9	47	0·488	217·5	+19·8	255·6	−29·2	451	2999
16	9	40	0·859	248·4	+58·5	254·9	−28·1	256	2288
17	12	10	0·938	241·3	+70·4	252·3	−29·3	139	1433
18	11	58	0·986	240·6	+82·5	251·3	−30·1	84	1389

The great spot was on the central meridian February 11, 22^{h} G.C.T. On February 13, when the group was best seen, being then nearer the centre of the disc than on any of the other days of observation, the group extended in heliographic longitude from 270° to 245°, a length of 25°; and in heliographic latitude